MTM

The Journal of Methods-Time Measurement

MTM ASSOCIATION FOR STANDARDS AND RESEARCH

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MTM

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The Journal of Methods-Time Measurement is dedicated to the technical aspects, application developments and general news items concerning the advancement of MTM.

The Journal encompasses the fields of endeavor that were formerly publicized in the MTM Newsletter and MTM Bulletin.

The technical section of the Journal is concerned chiefly with recent research developments both from the established research program at the University of Michigan, Ann Arbor, Michigan, and from somewhat smaller allied projects being conducted throughout the Association membership.

New applications of MTM as well as refinements of established applications are presented in the Application Section to illustrate specific approaches to management problems that can be solved through the use of Methods-Time Measurement.

Current events in the lives of persons associated with MTM are described in the general news section.

The Editorial Staff welcomes contributions for all three sections described.

Directors was approved several months ago, and the Executive Secretary was authorized to issue new Simplified M. T. M. Data Cards which will conform essentially to the passout sheet you were given as you entered today (see Figure 1).

This procedure has been described because it shows how any person or agency who can or has done work in the field of motion-time research which is believed to be of value to the M. T. M. system can answer the official invitation to submit full information to the Research Committee of the M. T. M. Association. Such efforts will be fairly evaluated, accredited, and - if having sufficient merit - sent to the Board of Directors in the same manner follwed in the Simplified Data project already described. Perhaps someone in this audience will make worthwhile contributions to predetermined motion times in this manner, and he is urged and welcomed to do so. (Project Slide #2, ¶1, p. 21 of 1956 Conference Proceedings). A standard format to facilitate such data submission is shown here.

Proceeding to the technical aspects of the simplified data revisions, the basic procedure closely paralleled that used by the originators of M.T.M. to develop the initial version, which Messrs. Maynard, Stegemerten, and Schwab reported in their textbook published in 1948. The entire set of data was recalculated, plotted, and examined for simplifying clues to see what could be done to improve it. The results were then validated by the Training Committee using motion patterns from training courses, examinations, and industrial samples submitted by its members. The nature and extent of the changes later adopted will now be shown in summary. (Project Slide #3 - 1956 Conference Proceedings.)

Here is shown a comparison of the old and new simplified Reach and Move data. Note that the main change was a reduction in the ways to compute the time from the distance, permitted by the new detailed data for Short Reaches and Moves. Another item was the new inclusion of a simplified weight factor for loads in excess of 5 pounds that resulted from an equation in the long research on Move with Weight. The new simplified version is obviously easier to remember and more readily applied. (Project Slide #4, 1956 Conference Proceedings.)

Here we see the old and new values for Turn and Apply Pressure. In both cases, the change better approximates the arithmetical averages of the detailed data as it now exists. More specific reasons are listed on the slide. Project Slide #5, Proceedings.)

This slide shows that the time value for the simple type of pickup grasp was increased by 1 T. M. U. because of the better information on short finger motions now available. (Project Slide #6, 1956 Conference Proceedings.)

The final change was the inclusion of a time value for RL1, Release in the new version of Simplified M. T. M. Data. Release was noted in the earlier version, but no time was assigned to it. (Project Slide #7, Proceedings minus note regarding approval at bottom).

With the changes shown in the other slides, the new Simplified M. T. M. Data for Hand and Arm Motions appear as listed here. For this listing, as well as a listing of the Body and Other Motions for which no change was found necessary, please refer again to your passout sheet. For those who attended the sessions at the last two conferences, there should be no difficulty in applying this new officially recognized form of the Simplified M. T. M. Data where it is appropriate.

<u>Position Research Progress</u>

Because it is one of the most complex and time-consuming motions in the entire M. T. M. system, the present research project of the M. T. M. Association concerning the basic element Position has taken the most time and effort of any research to date. This work is nearing completion, however, and three reports of the whole project are expected to be published this year. The first, covering the Laboratory Phase with the conclusions it produced, should be available within several months. It is instructive to note here that all formal M.T.M. research projects utilize a laboratory study to isolate the variables, test them for relative importance and validity, and to determine the direction and extent of work needed to arrive at useful M. T. M. time data for the motion under consideration in the Industrial Phase of the project, which will be covered in the second report. The third Position report will concern recommendations for assimilating the results of both the laboratory methods data and the industrial time data into the MTM procedure, together with any changes in either basic data or analysis approach suggested by the project.

For your information, these reports are issued cooperatively by the Engineering Research Institute of the University of Michigan and the M. T. M. Association. They do not represent official data, however, when they are first made available for public information; rather, they constitute public accounting for the project with

the intent of stimulating trial usage leading to submission of the results of such trials to the Research Committee of the M. T. M. Association. Perhaps some of you may care to take this step when the research reports are available on the Position project. The next normal action is a careful evaluation by the Research Committee of such feed-back data, the original project reports and data, and consideration of the effects of the report recommendations on the M. T. M. system and industrial usage of the data proposed. The report of the Research Committee to the Board of Directors will then be the basis for their action on the project, since only this board is empowered to make official data changes and publish them following careful study of all the data submitted. The responsibility of assuring users of M. T. M. that the data they employ is reliable is regarded as a sacred trust by the M. T. M. Association.

Today, we will give attention to the data included in the first, or Laboratory Phase, report on the Position project, the manuscript copy of which I have studied in some detail. It is a scholarly work affording ample evidence and proofs that any new official data which might result from the project rests on very sound experimental and mathematical grounds. The main features of this section of the total report were already publicly announced. I will attempt merely to summarize the more important facets for you.

One of the aims of the project was to check the validity of the present official Position data; indeed, the motion data and times encountered in any research project sponsored by the M. T. M. Association are continuously added to the master deck (Keysort cards) of the motion data files. It is reassuring to note that, as has been true of all research into M. T. M. since the original data was published, no major discrepancy was found in the accuracy and reproducibility of the existing data, considering the experimental procedures and measuring units on which the earlier data was based. In other words, the present Position data is valid as far as it goes; however, the classifications and cases were found to lack the flexibility and sensitivity required timewise and methodswise to properly evaluate many of the actual Positions frequently observed in industry. More and finer subdivisions of the basic motions comprising Position are needed. This led the research into a very basic investigation and analysis of the minute, short motions in Position from both the methods and time standpoints. I will show here the tentative conclusions reached and the probable future form of the Position elements in M. T. M. analysis and time allowance.

It will be helpful to start with a basic definition of Position as follows:

> "POSITION is the basic manual action by which two or more objects are aligned, oriented, and engaged in a definite physical relationship with motions of such short distance or nature as not to justify analysis as independent basic elements."[1]

According to this definition, Position motions may be accounted for fully by directing attention to the acts of Align, Orient, and Engage of which the element is composed. Actually, some consideration must also be given to the Move of the object to be positioned within half-an-inch or so of the destination prior to the start of the Position element itself. (Figure 2)

Here positioning motions are subdivided into Transporting and Adjustive. The Transporting motions consist of the Move already mentioned (which is really not part of the Position element itself) and of Engage motions. The latter are further subdivided into Primary Engage, which brings the object to the surface of the destination, and Secondary Engage, which seats the object into the destination in cases where the particular Position being analyzed involves insertion. Adjustive motions include Orient, which covers rotational adjustment of the object for mating with the hole, and Align, which accounts for any required linear adjustments. That the components mentioned are valid and significant classifications of the motions occurring during Position is smply confirmed by the Position research.

The research also established fundamental facts regarding the variables on which these sub-motions are most dependent, as well as relationships between them that provide clues of the variety of methods by which to effect a Position. Depending on the Class of Fit and Case of Symmetry between the objects, the present data provides 9 rigid caregories, besides restricting the insertion covered by Position times to 1" or less. The new data, however, accounts for Fit and Symmetry as they individually affect Align, Orient, and Engage together with a better gage of varying insertion depths. (Figure 3)

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[1] "ENGINEERED WORK MEASUREMENT," by Delmar W. Karger and Franklin H. Bayha, to be published soon by The Industrial Press, New York City.

This slide shows a tentative new form of the type of Position table likely to result from the research. The basic change will be that, rather than choosing from 9 defined categories as at present, the analyst will need to examine what happens regarding Align, Orient, and Engage. He will then assign the individual times appropriate to the actual variables and total these to arrive at the desired Position time. Note that the proven variables are:

(1) Fit and Symmetry for Align,
(2) Symmetry only for Orient,
(3) Fit only for Primary Engage, and
(4) Fit and Hole Depth for Secondary Engage.

Effectively, a table like the one shown will allow the analyst to arrive at a maximum number of 144 Position times instead of 9; this will remove the criticism of lack of sensitivity sometimes ascribed to the present data. (Figure 4)

To show that the new time tables might take some other form to account for the same variables, your speaker made the arrangement shown in this slide. You can see that 27 individual time values, none of which is repeated in the listing as was true of the other arrangement, would be the individual time blocks from which the total Position times are built. These 27 time values, of course, are dependent on the assumption of three classes of Fit, three cases of Symmetry, and four variations of Hole Depth. If more divisions of each variable are found necessary or desirable when the industrial data is analyzed to construct this type of table, an even larger number of Position times would be possible. Incidentally, submission of such an alternate table design to the Research Committee would constitute one type of cooperative effort that is welcomed, as was described under Simplified M. T. M. Data.

Having seen the nature of the new Position time data to come, it is equally or more interesting to discuss the vital methods information accruing from the research. Remember, the hyphenation of Methods-Time Measurement emphasizes the necessity for lucid methods thinking and analysis prior to the establishment of any meaningful time value for a given method. (Figure 5)

Of prime importance to methods analysis of Position is the possibility emerging from research of expressing positioning motions in a generic equation that also offers working guides to determining the nature of any given Position observed. As mentioned earlier, such an equation must refer to both the motions included in Position and also the precise, Case C Move preceding it. This equation is:

$$M + P = (M + 0) + (E_1 + A) + E_2.$$

The parentheses are significant in that they show the manner in which positioning elements can be combined or limited in the motion-time sense. Note that Orient can occur either alone internal to the Position element, or it may be wholly or partially performed during the preceding Move. Primary Engage and Align can also be either combined or done independently. Only Secondary Engage must always be unaccompanied, as logic would indicate. The research has almost completely validated these statements for the first time, although the original M. T. M. data was largely based on the same thinking and practice. (Figure 6)

Consideration of these facts leads to the demonstration that Position can occur in any of at least four ways, depending on the generic equation. In this slide, a slanted line is used to show when limiting action occurs. The possibilities become:

(1) $M + 0 + E_1 + A + E_2$ This is the most general case in which all of the components are done separately in the order listed. The time required, therefore, would be the sum of the times for each action.
(2) $(M + \emptyset) + E_1 + A + E_2$ In this type of Position, all motions are independent except that the Orient is limited out by the Move preceding Position, having been performed concurrently. Orient time would then be excluded.
(3) $M + 0 + (\cancel{E}_1 + A) + E_2$ Note that Primary Engage has been performed in combination with Align, and is therefore not included in the total Position time.
(4) $(M + \emptyset) + (\cancel{E}_1 + A) + E_2$ For a given fit and symmetry, this Position method will yield the least time because both the Orient and Primary Engage have been limited out - or accomplished during - the preceding Move and Align elements, respectively.

When it is seen that this new methods information, together with a selection of more time values and finer determination of the basic variables of fit, symmetry, and hole depth, will lead to better evaluation of observed Positions, the value and importance of the Position research is easy to imagine.

M. T. M. Association Activities

In a sense, what I have to report concerning the national activity of the M. T. M. Association is not exactly news so much as it is evidence of its vigor and vitality, resulting in dynamic growth and public service. It now functions with a great diversity of industrial firms of the highest caliber among most major lines of industrial pursuit. To illustrate, I quote the current membership as follows: One Honorary member (the only surviving Industrial Engineering pioneer, Dr. Lillian M. Gilbreth); 13 Associate members of the teaching profession; 10 Chapters including Canadian, Swedish, and Swiss; 13 Professional members, which are consulting firms in the U. S. and Canada; and 94 Sustaining members, all dues from which are devoted to the research activity of the Association. Among the Sustaining members, one finds: 1 college; 14 governmental agencies; 64 domestic industrial companies; and 15 foreign firms that include 8 Canadian, 4 European, 2 South American, and 1 South African. Examinations for recognition cards qualifying students for M. T. M. application ran at the rate of over 100 monthly during 1956. There are now more than 134 approved instructors, such as myself, with 20 new instructors having been qualified in 1956. The inauguration of an annual Practitioner's Seminar at the Annual Conference last year was very much a success and promises to improve the work of these instructors in the future. The national body is in fine condition according to these statistics.

Perhaps you noted the references made to foreign usage of M. T. M., which truly is bursting the confines of the North American continent. Actions have been taken toward the formation of an International M. T. M. Association during the third week of June at Paris, France in conjunction with the C. I. O. S. conference. This is an international gathering of management experts functioning under the United Nations. Certified National Status (CNA) has already been granted to M. T. M. Svenska, Sweden. During this year, CNA status is anticipated for M. T. M. Genootschap, Holland, the French M. T. M. Association, and the Swiss M. T. M. Association. The original M. T. M. textbook has been translated into more than 12 foreign languages, which is further evidence of foreign usage. M. T. M. Svenska has undertaken the basic research project covering Grasp motions. These indications of the universality of M. T. M. surely imply that it is a sound motion-time system of high value to management and industrial engineers.

Other news of interest concerns the results of a survey of institutions of higher learning as to the extent and amount of M. T. M. training being given. More than 20 colleges and universities said they taught M. T. M. in some manner. It was included as part of a general course in more than 90% of these schools and the time devoted to M. T. M. averaged over 12 class hours. Some 28% even included separate courses on M. T. M. consuming an average of about 60 class hours exclusive of laboratory or homework. It was estimated that over 1,650 persons were being reached with M. T. M. information annually, based on an average of 61 in general courses and 23 in separate courses being taught at these institutions. This is remarkable, since the M. T. M. Association was started only 6 years ago and the original textbook appeared only 9 years ago. Also, the comparison of increase between the 1954 and 1956 surveys showed about 50% greater M. T. M. training activity involved.

Motion Research With an Analog Computer

Finally, I wish to report that "automation" thinking is invading the field of motion-time research. Many investigators have devised various schemes and mechanisms to accelerate the rate and quality of research data available for practical interpretation and application. In accordance with this trend, the M. T. M. Association applied funds granted from the Maynard Foundation to make a Feasibility Study of the use of an electronic analog computer for MTM research. To bring into being the system found feasible, as described here, funds are being solicited from major foundations in this country. (Figure 7)

This diagram shows the elements of the proposed AIPAR (Automatic Instrumentation Data Processing and Recording) system which the M. T. M. Association hopes to build and operate as soon as funds are available. All components are already commercially obtainable except those connected with the first function of sensing, which would require developing one of several alternatives already isolated. The motions most likely would be sensed by a Tri-Axial Accelerometer (TXA) and fed as an electronic signal into the Analog Computer for amplification, integration, and synthesis. The computer output would operate an Oscillograph Recorder which would automatically draw curves for displacement, velocity, and acceleration. From these curves could be obtained practical methods and time data similar to that which results from the current cumbersome and time-consuming M.T.M. research methods. An optional feature of the system would consist of a Digital Voltmeter, Translation Matrix, and Gag Summary Punch which could produce punched cards similar to those presently employed in M. T. M. research;

this feature would permit enlargement of the master data file now existing and make available for ready reference each individual motion performed in even complex routines.

The TXA device specified was selected from approximately eight approaches to the sensing problem which were included in the Feasibility Study. It would involve attaching minute patches sensitive to motion at various locations on the worker such that three- dimensional input signals would be passed through fine wire into the computer. Recall that, mathematically, velocity is the first integral of distance or displacement, while acceleration is the second integral. Essentially, the computer would match the tri-axial displacement signals against a synchronous timing mechanism to enable derivation of the two integrals in a continuous manner. Various problems of mounting, correction, calibration, and psychology are basically what must be solved to make the TXA approach effective. Since these seemed easier to surmount than problems connected with such sensing elements as the Doppler effect, piezo-electric strain gages, sensitive potentiometers, television cameras, and various other sensing possiblities, the TXA approach was the one selected for development.

The principal gain from the computer approach to motion-time study would be in the matter of speed, accuracy, sensitivity and volume of data to be analyzed. This would not be an unmixed blessing, since the analysis phase of the work would need streamlining to keep up with the rapid output of the computer system. But in the belief that the gains would far outweigh the problems generated, the M. T. M. Association feels this is the best way to reduce data error and achieve research results to guide practical application years sooner than otherwise. It is hoped that the needed funds will be found soon and this work can proceed.

SIMPLIFIED METHODS-TIME MEASUREMENT DATA

----- including symbols -----

(All times in this Simplified Data Table include 15% allowance)

HAND AND ARM MOTIONS

Motion and description	TMU	Symbols
REACH (x = length reached, inches)		
Regular ----------	3 + x	Rx
In motion --------	x	mRx
MOVE (x = length moved, inches)		
Regular ----------	3 + x	Mx
In motion --------	x	mMx
Weight (over 5#), 1/2 per #		- #
GRASP		
Simple -----------	3	G1
Regrasp ----------	6	G2
Transfer ---------	6	G3
Complex ----------	10	G4
RELEASE	2	RL1
POSITION		
Loose fit-Symmetrical	10	P1S
-Other	15	P1NS
Close fit-Symmetrical	20	P2S
-Other	25	P2NS
Exact fit-Symmetrical	50	P3S
-Other	55	P3NS
DISENGAGE		
Loose fit --------	5	D1
Close fit --------	10	D2
Exact fit --------	30	D3
TURN	8	T
APPLY PRESSURE	15	AP

BODY AND OTHER MOTIONS

Motion and description	TMU	Symbols
SIDE STEP		
Case 1 ----------	20	SS1
Case 2 ----------	40	SS2
TURN BODY		
Case 1 ----------	20	TB1
Case 2 ----------	45	TB2
BEND, ARISE	35	B, AB
STOOP, ARISE	35	S, AS
KNEEL		
On One Knee -----	35	KOK
Arise -----	35	AKOK
On Both Knees ---	80	KBK
Arise -----	90	AKBK
SIT	40	SIT
STAND	50	STD
WALK (x = paces taken)	17x	WxP
LEG MOTION	10	LM
FOOT MOTION		
Simple ----------	10	FM
With pressure ---	20	FMP
EYE TIME	10	E

1 T.M.U. = .00001 Hour
= .0006 Minute
= .036 Second

Revised 1957

Figure 1.

POSITIONING MOTIONS (Figure 2)

TRANSPORTING MOTIONS:

MOVE		Object near destination
ENGAGE -	PRIMARY	Object to surface of destination
	SECONDARY	Object seated into destination

ADJUSTIVE MOTIONS:

ORIENT	Rotational adjustment of object
ALIGN	Linear adjustment of object

HYPOTHETICAL POSITION TABLE (Figure 3)

CLASS OF FIT	ALIGN - A			ORIENT - 0			ENGAGE				
	Case of Symmetry			Case of Symmetry			PRIMARY - E_1	SECONDARY - E_2 Hole Depth, inches			
	S	SS	NS	S	SS	NS		0	1/2	1	1-1/2
1	A_1	A_2	A_3	0_1	0_2	0_3	E_{11}	E_{21}	E_{22}	E_{23}	E_{24}
2	A_4	A_5	A_6	0_1	0_2	0_3	E_{12}	E_{25}	E_{26}	E_{27}	E_{28}
3	A_7	A_8	A_9	0_1	0_2	0_3	E_{13}	E_{29}	E_{30}	E_{31}	E_{32}

ALTERNATE DESIGN OF HYPOTHETICAL POSITION TABLE (Figure 4)

	ORIENT - 0			ENGAGE					CLASS OF FIT
	0_1	0_2	0_3	PRIMARY - E_1	SECONDARY - E_2 Hole Depth, inches				
	Case of Symmetry								
	S	SS	NS		0	1/2	1	1-1/2	
ALIGN-A	A_{11}	A_{21}	A_{31}	E_{11}	E_{21}	E_{22}	E_{23}	E_{24}	1
	A_{12}	A_{22}	A_{32}	E_{12}	E_{25}	E_{26}	E_{27}	E_{28}	2
	A_{13}	A_{23}	A_{33}	E_{13}	E_{29}	E_{30}	E_{31}	E_{32}	3

GENERIC EQUATION FOR POSITION (Figure 5)

$$M + P =$$

$$(M + 0) + (E_1 + A) + E_2$$

METHODS OF POSITION (Figure 6)

(1) $M + 0 + E_1 + A + E_2$

(2) $(M + \emptyset) + E_1 + A + E_2$

(3) $M + 0 + (\cancel{E}_1 + A) + E_2$

(4) $(M + \emptyset) + (\cancel{E}_1 + A) + E_2$

DIAGRAM - MOTION ANALYSIS COMPUTER (Figure 7)

EQUIPMENT	FUNCTION
TRI-AXIAL ACCELEROMETER (TXA)	SENSE MOTIONS IN THREE COORDINATES
AMALOG COMPUTER	AMPLIFY INPUT SIGNALS, INTEGRATE, AND SYNTHESIZE RESULTS
OSCILLOGRAPH RECORDER	RECORD RESULTS. CAN BE PRINTED DATA OR CONTINUOUS CURVES DRAWN AUTOMATICALLY
(OPTIONAL)	
DIGITAL VOLTMETER TRANSLATION MATRIX GANG SUMMARY PUNCH	RECORD RESULTS. OPTIONAL DEVICES THAT PERMIT AUTOMATIC PUNCHING OF COMPUTER CARDS.

TECHNICAL

AN ANALYSIS OF RESEARCH INTO POSITION

by

John W. Punton, Director of Research
Methods Engineering Council

For some time the MTM element Position has been the object of considerable discussion, investigation, and theorization. The reason, of course, is obvious. The Position table on the MTM Data Card provides just eighteen time values for this element, and the per cent difference between them is large in many instances. In using these values to set time standards on highly repetitive operations in which a large per cent of total operation time is due to Position, any inaccuracy in the time values for Position becomes readily noticeable.

Recently, the results of a carefully conducted research study by John S. Kernachan of Pennsylvania State University have been printed. Mr. Kernachan conducted his study as a partial fulfillment of the requirements for a Master of Science Degree. His resulting thesis is titled, "A Study of the Effect of Entry-Clearance on the Time Required for the Motion Elements Comprising Position."

Research Study Objective:

Mr. Kernachan's basic reason for undertaking a study of Position was that he felt it might not be as stated in its definition a "basic element" in which "the motions used are so minor that they do not justify classification as other basic elements." Instead he felt that Position is "a combination of several more fundamental elements" and that "unless the individual times for all elements are known, it is doubtful if satisfactory time standards can be set for all cases of Position."

The experienced MTM practitioner will probably protest at this point that MTM does recognize Position is not a basic element. Doesn't the theory of Position point out that it is composed of an alignment element, an engagement element, and frequently an orientation element? Yes, it does, but it is also true that the MTM text book published in 1948 established only one time for the Align element - 5.6 TMU. It treated the orientation element as a variable by establishing three cases of symmetry. It also treated the engagement as a variable by creating three classes of fit. However, it recognized only one time value for alignment at that time.

The Research Equipment:

Mr. Kernachan planned his research study to provide information on the alignment portion of Position in particular. He also planned to obtain data on each of the other elements involved. He selected the simple operation of inserting a round steel pin into a steel bushing. As his variable he used the length of taper on the end of the pin entering the bushing. He kept the angle of this taper constant at 45^{o}, but varied its length as shown in Figure 1. By so doing he created four cases of entry-clearance.

By entry-clearance, Mr. Kernachan meant the difference between the bushing diameter and the pin diameter at the end entering the bushing. Since his bushing was accurately machined to an inside diameter of 0.7525" and the body of his pins, to a diameter of 0.747" plus or minus 0.0005", the difference between a pin body diameter and the bushing diameter was somewhere between 0.005" and 0.006". The effect of the tapers, however, was to create a much greater clearance at the beginning of the Assemble element. For example, pin 1 came to a point at the end inserted into the bushing. Therefore, the entry-clearance between it and the bushing was the diameter of the bushing or 3/4". Pin 4, on the other hand, had an end diameter of 21/32", and its entry-clearance with the bushing was, thus, approximately 3/4" less 21/32" or 3/32".

As Figure 1 illustrates, Mr. Kernachan chose the length of taper on each pin so that the entry-clearance for Pin 2 was half that for Pin 1; Pin 3's was half that for Pin 2; and Pin 4's was half that for Pin 3.

You can understand the procedure followed by an operator performing Mr. Kernachan's experimental operation by looking at the top view of the work area illustrated in Figure 2. The operator removed a pin from the holding bushing "A", moved it to bushing "B", inserted it

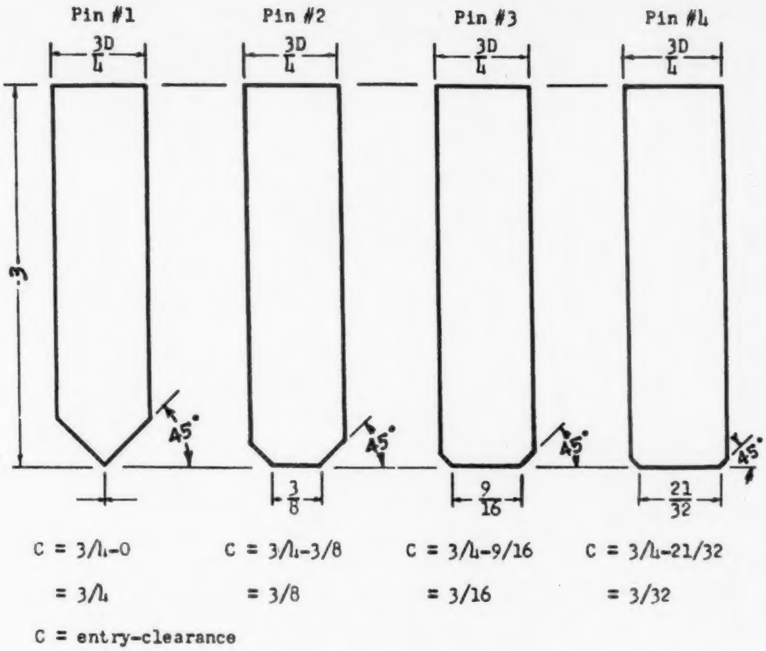

Figure 1. The Steel Pins

until it struck a stop located one inch below the top edge of bushing "B", and then returned the pin to holder "A". By means of a rather complex system of photoelectric cells and electrical circuitry, Mr. Kernachan was able to time various segments or elements of the operation. The time intervals for these elements were recorded by means of pens beneath which a paper tape passed at a constant velocity. Thus, the pens drew straight lines until a contact in the electrical circuit of which they were a part was opened or closed by the movement of a steel pin. Then the pen affected made a sharp jog in the straight line. Using the distance between such jogs and the velocity of the paper, Mr. Kernachan could quite accurately compute the time interval for elements of the operation.

The elements he measured were:

1. The time that elapsed between the instant a pin broke contact with the holder "A" (Figure 2) until it interrupted a beam of light passing 1" above the center of Bushing "B". This portion of the operation he considered Move.

   It is interesting to note at this point that he established a somewhat arbitrary point for the end of the Move and the beginning of the succeeding element, Align. The point chosen was when the leading edge of a pin traveling in a more or less horizontal direction arrived above the center of the bushing. Mr. Kernachan anticipated that a pin might approach the bushing along a more vertical path. In this event his timing equipment would have reacted when the end of the pin reached a point 1" above the bushing. He points out regarding this alternate path of approach that "This, however, was never observed to occur."

Another interesting point to consider is the type of Move that he measured. The characteristics of the pin holder "A" (Figure 2) are not explained fully in the thesis. If by "break contact with the holder" he means the point at which the end of a pin left the top edge of the holder, the pin would be in motion at that point. Consequently something similar to a Type II Move would have been measured. Furthermore, unless the pin had stopped its motion by the time it broke the light beam above the center of the bushing "B", the Move might even have been a Type III - in motion at both beginning and end. It is

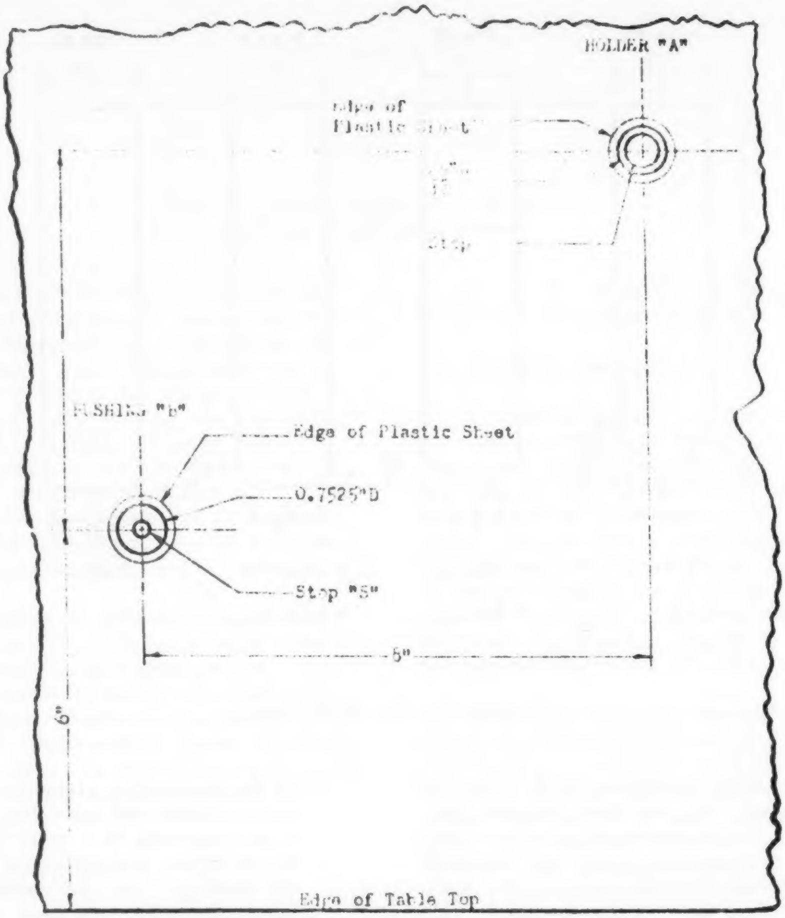

Figure 2. Arrangement of the Work Area

doubtful, of course, that the pin at either of these points was traveling at the maximum velocity assumed at the beginning or end of a Type III Move. It is more probable that its speed was lower than this maximum. Even so, the fact that any motion at all was taking place would lead us to anticipate a lower time value for these Moves than the time value for a Type I Move of the same distance.

The other time intervals or elements measured in Mr. Kernachan's study were:

2. The time that elapsed between the end of Move as described above and the instant at which the end of a pin interrupted a beam of light 1/4" wide and 1/16" high beginning 1/16" below the top edge of the bushing. This element he called Align.

   The construction of his equipment prevented measuring the point at which the end of a pin became even with the top of the bushing. Therefore a small portion of the Assemble element was included in the measured Align time values.

3. The time that elapsed from the end of Align as described above until the end of a pin touched a stop located one inch below the top edge of the bushing. This element Mr. Kernachan called Assemble.

   His equipment also timed one other point in the operation: The instant at which a pin first touched bushing "B". This information was useful as an indicator of

how well the operator aligned a pin before attempting to insert it into the bushing. It also enabled him to estimate the time required to insert a pin into the bushing the short distance necessary to break the light beam that registered the end of the Align element. This distance was 1/8" for all pins except / for which it was 5/32".

The Research Operation Plan:

Mr. Kernachan took pains to avoid any biasing of his results. He chose operators at random. Some were laborers and some were college students. Each had a reasonable amount of practice opportunity on the operation before the timing of the experiment began. The order in which each of the four pins was used by each operator was also established on a random basis. Furthermore, the number of cycles for each pin was sufficient to provide a reliable sample of data. The only precaution he might have taken but didn't was to have rated the performance of each operator. By so doing he could have converted all times used to perform the operation to the same performance level. So long as all of the operators performed at about the same level, his data should be comparable within itself. However, without performance rating any comparisons with MTM time values are questionable. In other words, so long as Mr. Kernachan's data are not construed to be normal times, but are used only to study the effect of entry-clearance on Move, Align, and Assemble under the condition of his study, the lack of performance rating presents no particular problem.

Results of Investigation:

To interpret the data gathered during his study, Mr. Kernachan applied recognized statistical techniques. His first step was to test whether entry-clearance had any effect on the time for each of the three elements: Move, Align, and Assemble. In the design of his statistical test, he permitted only a 5 per cent possibility of arriving at an incorrect conclusion. Thus, we can be reasonably confident that his conclusions are correct regarding whether or not the times for Move, Align, and Assemble are affected by entry-clearance.

As far as the Move element was concerned, Mr. Kernachan's statistical tests "did not reveal any relationship between entry-clearance and the time required - - -". This is a particularly significant conclusion. Many critics of predetermined time systems condemn them because they do not recognize sufficiently the effect of preceding and following motions on the time for performing the intervening motion. Mr. Kernachan's research shows that there is no such influence on Move time due the entry-clearance between objects involved in a following Position element.

His statistical tests did show that both Align and Assemble were affected by entry-clearance, however, and that the effect was a linear one. He is careful to point out that this linear relationship may be true only for the conditions considered in his study. This is especially the case in regard to the Assemble element for, to quote Mr. Kernachan, "Assemble is probably also dependent on the coefficient of friction between the pin and the bushing and the clearance between the pin shank and the bushing."

Therefore, the only conclusion that can be reached from the data on the Assemble element is that entry-clearance does have an effect upon the time required for this element. Although this effect may not be linear, it is appreciable and cannot be ignored. From the study, it required about 42 per cent more time to Assemble Pin 4 than Pin 1, for example.

I cannot agree with Mr. Kernachan, however, that "in the methods-time measurement system, the time allowance for all four pins would be the same." The MTM practitioner, I feel quite sure, would not allow the same class of Position for each pin. The MTM text book, for example, states that "A good rule to follow is to consider that a Position occurs when the difference in size between mating parts at the point of initial engagement is one-half inch or less." Thus, the insertion of Pin 1 into the bushing would not even be classed a Position. Furthermore, since MTM does not attempt to distinguish between Align and Assemble, except in theory, it is not possible to state how much of any Position time that is allowed is attributable to the Assemble element. One of the primary reasons for there being a composite Position element in MTM is that its originators found it "impossible to make the separation accurately and consistently" between Assemble and the aligning and orienting that are called Position under the Therblig system of motion analysis.

Since Mr. Kernachan's study was really designed to determine the effect of entry-clearance on the Align portion of a Position, it is desirable to look closely at his findings in this area.

As we discussed earlier, the beginning of the Align element as measured by Mr. Kernachan probably occurred before the Move had completely stopped. To bring the centerline of the

pin above the center of the bushing, for instance, required approximately 3/8" more horizontal travel (the radius of the pin) after the measured beginning of Align. Furthermore, a certain amount of vertical travel was necessary to bring the end of the pin 1/8" below the top of the bushing thus indicating the end of Align. He has estimated the straight line motion required during Align at about 1/2". Since the preceding Move is 12" long, he has further estimated that the additional time for a 1/2" increase in the length of that Move is 0.4 TMU. Comparing this estimated additional time with the average recorded time for all Align elements, he states, "it could be surmised that on the average about 16 per cent of the recorded Align time actually is Move time."

Whether or not this is an accurate conclusion is not too important in so far as conclusions about the effect of entry-clearance on Align are concerned. This is true because the effect of this Move time is only to add a constant value to what otherwise would be the basic time for Align. This addition of a constant time would, of course, affect the magnitude of the Align element, but not the difference between the times obtained in the Study for different pins. It is from these differences that Mr. Kernachan drew his conclusions.

During his investigation, Mr. Kernachan encountered certain cycles of the operation which he classified as irregular. These were the cycles in which a pin contacted the bushing before breaking the light beam that marked the end of Align. As might be expected, the number of irregular cycles increased in relation to the regular cycles as the entry-clearance decreased. The significance of these irregular cycles was that they provided Align times larger than those for corresponding regular cycles. For Pins 1 and 2, the inclusion of Align time values for the irregular cycles with those for the regular cycles served to increase the average time for the regular cycles alone by less than 1-1/2 per cent. This is negligible as he points out. However, the result of doing the same thing for Pins 3 and 4 was not negligible. The average time for Aligning Pin 3 increased over 10 per cent and the time for Pin 4, nearly 23 per cent. He points out, "if a criterion for a predetermined time system is that the system is to be consistent within plus or minus five per cent, then certainly no factor can be omitted from the data which affects the time required for an element by ten or more per cent." Probably no one will object to this reasoning. It is well to note, however, that in order for knowledge of the effect of irregular cycles to be of practical value, there must be some way of classifying operators and jobs in terms of their irregularity. The possibility he raises that the effect of practice may be to reduce the number of irregular cycles is an interesting one to contemplate. Certainly it agrees with the leveling concept of skill in which fumbles diminish as skill increases. However, until further research provides a way of determining both the magnitude and frequency of these irregular cycles for any specific operation or operator, the knowledge that they occur is little more than interesting.

In an effort to remove from the time for Align recorded by his apparatus the time consumed in moving a pin the short distance into the bushing necessary to interrupt the light beam, Mr. Kernachan compared Align times from the regular cycles with that portion of the Align time for irregular cycles that ended when a pin struck the bushing. The difference between these two times he reasoned, was the time required to Move a pin from the top edge of the bushing into it sufficiently far to break the light beam that indicated the end of Align.

Using this concept, he subtracted the small Move time from both the regular and irrecular cycle Align times. He also added this same increment of time to the Assemble element where it actually belonged. Thus, the Align times remaining represented the time elapsing from the instant the forward edge of a pin interrupted the light beam passing above the center of the bushing until the end of that pin came even with the top of the bushing.

Table 1 records the results of the analysis of Align time for each pin as well as for the Move preceding, the Assembly following, and the total Position. The correction to Align and Assemble times mentioned above has been made in this table.

Summary of Experimental Results:

In summarizing the conclusions drawn from his investigation, Mr. Kernachan makes the following statements:

1. "The figures in Table 1 are the best estimates of the time for Align that can be obtained from the data of this study."

2. "Assemble time is not considered a function of entry-clearance but is rather a function of another variable."

3. "For Move as measured in this study - at the 95 per cent confidence level it could not be stated that the time for Move was affected by entry- clearance."

Table 1

SUMMARY OF EXPERIMENTAL DATA IN TMU's

Pin No.	Regular	Irregular	Combined
Move			
1	10.9	10.4	10.9
2	10.7	10.6	10.7
3	11.0	10.8	10.9
4	11.2	11.1	11.1
Align			
1	1.5	2.3	1.5
2	1.6	3.0	1.7
3	2.2	4.0	2.8
4	2.6	5.3	4.3
Assemble			
1	3.4	4.6	3.5
2	4.4	4.0	4.3
3	4.6	4.8	4.7
4	5.7	6.1	5.9
Total Position Time			
1	4.9	6.9	5.0
2	6.0	7.0	6.0
3	6.8	8.8	7.5
4	8.3	11.4	10.2

Adapted from Tables VI and VII of Mr. Kernachan's thesis. The Align and Assemble time values have been modified to remove any Assemble time from Align time as measured in the research study.

In analyzing these conclusions, it is interesting to compare them with MTM recognizing, of course, that the study times are not leveled. Mr. Kernachan points out that, "In some cases the time for Align could comprise the entire time for Position. If, for example, two parts are merely brought into contact and no Assemble follows, the time for Position in the case of Pin 1, would be 1.5 TMU (Table 1). If the Position with Pin 1 involved a 1 inch engagement, the time from the data in Table 1 would be 1.5 TMU plus 3.5 TMU or a total of 5.0 TMU. This 5.0 TMU value is 333 per cent greater than the 1.5 TMU value; yet both cases would be assigned the same time under the present methods-time measurement data."

Mr. Kernachan has, of course, hit upon an area of MTM that certainly bears further investigation. It is an area that has concerned many MTM practitioners for some time and fortunately is one which current research by the MTM Association promises to clarify to a great extent. It is well to keep in mind, however, that although the time difference expressed as a percentage appears extremely large, the amount of time involved is only 3.5 hundred thousandths of an hour or 0.13 seconds. Only in extremely short cycle, highly repetitive operations would such difference in Position time become meaningful.

In connection with Positions that do not involve Assembly, Mr. Kernachan also points out "Align, in some cases, comprises the entire Position time, and where this is true, entry-clearance could influence the Position time by as much as 287 per cent. The indication of this experiment is that entry-clearance has such a pronounced effect on the time for Position that it will have to be considered in all predetermined Standard time systems."

MTM practitioners, of course, recognize that MTM does consider the variable of entry-clearance through the means of the class of fit. The rules given for Alignment type Positions in the MTM training course approved by the MTM Association are listed in Table 2. These rules are also applied to engagement-type Positions. While it is debatable whether sufficient recognition of the effect of entry-clearance is provided by these rules, I believe the comparison in Table 3 based upon them is a much more realistic appraisal of MTM's accuracy than Mr. Kernachan's indication of a possible 287 per cent error.

Table 2

RULES FOR ALIGNMENT TYPE POSITIONS

Accuracy of Alignment	MTM Motion Required
$\geqslant$ 1/2"	M - B
$<$ 1/2" to 1/4"	M - C
$\nleq$ 1/4" to 1/16"	M - C + P1SE
$\leqslant$ 1/16"	M - C + P2SE

It is interesting to consider, too, that the rules given in Table 2 provide only points along a curve and that intermediate time values can be obtained by interpolation if desired. For example, a P2SE is noted as beginning when the alignment accuracy required (entry-clearance)

Table 3

COMPARISON BETWEEN THESIS TIME VALUES AND MTM TIME VALUES

Pin No.	MTM Pattern	MTM Time (TMU)	Thesis Time (Table 1)	Per Cent Difference
1	M13B	14.0	15.9	- 12.0
2	M13C	16.0	16.7	- 4.2
3	M12C + P1SE	20.8	18.4	+ 13.0
4	M12C + P1SE	20.8	21.3	- 2.3
		71.6	72.3	- 0.97

is 1/16 inch, and a P1SE when it is 1/4". Reason would indicate that if these two points are accurately established, the Position employed when the required alignment accuracy is 1/8 inch should have a time value approximately half way between the values for a P1SE and a P2SE.

There is no question in my mind, however, that despite the recognition MTM already takes of the effect of entry-clearance, even more is desirable. Mr. Kernachan's criticism in this regard is certainly justifiable. On the other hand, it is disturbing to me that those conducting research into the validity of MTM do so without having obtained officially recognized training and guidance in the application of the technique. While I believe Mr. Kernachan's study was well planned, was carefully carried out, is quite well explained in his thesis, and points out the need for further research into MTM application, I also believe his occasional incorrect interpretations of the use of MTM result in unjustified and misleading criticism.

One final comparison of Mr. Kernachan's results is of interest. The average time for the Moves of the four pins as listed in Table 1 is 10.9 TMU. Since this Move is approximately an M12C according to MTM, the corresponding time value from the MTM data card would appear to be 15.2 TMU. However, recalling that the Move as Mr. Kernachan measured it was probably somewhat in motion at its beginning as well as at its end, its MTM classification would more correctly be at least an M12 Cm. The time value for this Move is 11.8 TMU. Thus, the agreement between Mr. Kernachan's 10.9 TMU and the estimated 11.8 TMU is quite close. To me this is a tribute not only to the basic adequacy of the MTM data but also to Mr. Kernachan's careful research work.

APPLICATION I

TIME STUDY ANALYST - GET TO WORK ON MATERIAL HANDLING

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The "Handbook of Industrial Engineering and Management"[1] states that "the cost of materials handling in all forms accounts for from 20 to 50 per cent of the total cost of converting the raw materials into finished product." Further: "It is not uncommon for each part to be handled as many as 50 to 60 times before it is in final form and shipped." When we consider these facts, we can see that the question is not: "Should the time study analyst go to work on material handling?" but rather, "How soon should he start, and what techniques should he use?"

We will limit this discussion to the "transport"[1] type of materials handling which we will define as the movement of materials between work stations or storage locations as differentiated from the "transfer" type which we will define as the movement of materials within a workplace. It should be mentioned, however, that the transfer type of materials handling creates considerable cost for most companies.

Also, since we, as Industrial Engineers, realize that the highly conveyorized mass production factory certainly is not the prevalent form of manufacturing activity, we are going to confine this talk to applications in the "job shop" which seems to be much more typical.

Much has been written concerning the establishment of time standards for the "transport" type of materials handling.[2] Probably the most widely publicized data of this type is that prepared by the Yale and Town Manufacturing Company in cooperation with the Wharton School of the University of Pennsylvania.[3] One does not work with such data for very long without concluding that its application is limited to fairly standardized loading and unloading operations and cycled moves.

Standard elemental time data has been developed for all forms of material handling, and there is little question that the development and use of such data should be the ultimate goal of the time analyst when he approaches the material handling functions of his own company. However, at the present time many companies do not operate under standard material handling conditions which are necessary for the development and application of standard data for this activity.

Furthermore, even where such standards can be developed and applied they will not measure the total material handling cost. For much material handling is done by machine operators, foremen, set-up men and expeditors - not the personnel of the material handling department. Nor will standards set on material handling operations tell how much the delays associated with material handling cost.

Before we bravely, boldly and unfortunately sometimes foolishly step out, stop watch in hand, to solve all the problems of the material handling function with our times standards, we had better find the answers to such questions as:

Who is spending How Much Time on material handling?
What is the total labor cost attributable to material handling?
How much time is spent on each of the major elements of material handling?
Who is using What equipment?

Investigations of this sort are just as important a part of the time analyst's job as are the setting of standards and in many cases the former are much more challenging.

As an indication of one approach to determining the answers to the questions I have posed, I am going to discuss a study which was made at one of our "plants". This study was made by the staff industrial engineering group at the plant in cooperation with my office which serves as a management engineering training and consulting center for the Ordnance Corps and other branches of the Department of Defense.

Before I describe the mechanics of the investigation, I will relate a little background information.

The methods and standards section of this plant had developed extensive standard data for the production operations. However, a detailed cost analysis of the manufacturing division indicated that labor costs were not being adequately controlled due to lack of coverage in many of the so-called "indirect" areas, excessive amounts of work reported as being performed under non-standard conditions or off standard, low effectiveness ratios and frequent use of delay charges.

It was at this stage that my office entered the picture. To clear up the semantics, I will use the term "we" as meaning the staff industrial engineering section of the plant and myself.

Our first reaction was that we should embark on an extensive program of establishing standards for the indirect areas, of which material handling was going to be one of the first considered. After some deliberation, we decided that we should first appraise the entire time distribution of the manufacturing division personnel to ensure that our efforts would be made in the most profitable direction.

It didn't take us long to realize that neither the present cost accounting data nor the standards maintained in the methods and standards section would give us the required information, but that only by using a relatively new technique - Work Sampling[4] - could we obtain the answers to many of the questions confronting us.

Working sampling may be defined as: "A quantitative analysis in terms of time, of men, machines or any other observable state or condition of activity."[5]

That is, if we take enough random "looks" at a work situation and record what we see the people doing each time we look, the number of observations of each category of work are a good estimate of the percentage of time the people spend in each category of work.

The most important part of the study - the design - took place prior to the making of a single observation. We had to design our study so that it would provide us with all the information which we desired and at as low a cost as possible compatible with the requirements of statistical reliability. (The more observations we would make, the more reliable our study would become, but the more the study would cost.)

The first step in the design was to determine the categories of work which were to be sampled. We ask our analysts to list everything which they would like to know about the time distribution of the people in the areas where they were setting standards. Then, since the aim of this study was to provide information for all the members of the "management team", we held discussions with the various levels of supervision and members of the production control and accounting branches to determine what information would interest these people.

Once we knew the desired information, we started to establish consistent category definitions and a uniform numbering system so that we could classify and cross-classify our findings.

First we had to classify our working force. We decided that grouping people under the headings of:

Operators
Set-up men
Foremen
Material Handlers
Clerical
Sanitation

would be sufficient. Since we did not consider sanitation or clerical personnel in the material handling aspects of the study, we won't mention them further.

Next we decided that all activity could be grouped into three major categories:

Direct Production
Support to Direct Production
Delay

These categories were defined generally as follows:

1. <u>Direct Production:</u>
   Productive activity representing the major assignment of the individual. This usually is accomplished at one workplace and results in an end unit of production. Examples for labor classification are:
   Operators: At workplace operating equipment, using hand tools or assembling
   Material Handlers: Operating M. H. E.

2. Support to Direct Production:

Productive activity representing other than the major assignment of the individual. Frequently accomplished away from the workplace with the work unit not easily definable.

Examples of labor classification are:
Operators: Get Material
Material Handlers: Clean Equipment

3. Delay

All non-productive activity
Examples by labor classification are:
Operators: Wait for material handling equipment
Material Handlers: Wait for assignment

We can readily see that this gross breakdown would provide us with some useful information but certainly would not tell us all that we said we desired to know about materials handling. Our next step then was to divide these major categories into minor categories.

Since we are concentrating our attention on the transport type of materials handling, I'll only mention that one of the minor categories for direct production was get and place material (transfer).

Naturally, we had minor categories of direct production to represent the various types of materials handling performed by the material handling branch, but of more interest are the support and delay categories for other labor classifications which I'll mention in some detail.

The minor categories of support were as follows:

2.1 Clean-up
2.2 Preventive maintenance
2.3 Read instructions
2.4 Material handling
2.5 Get or return tools
2.6 to 2.9 As required for area

And for delay the minor categories were:

3.1 Personnel time
3.2 Wait for instructions
3.3 Wait for production equipment
3.4 Wait for M.H.E.
3.5 Conference
3.6 to 3.9 As required for area

Now with this information we could determine who was spending how much time on material handling. We could have stopped here and had a complete cost picture. However, in order to have more analytical information at our disposal, we continued to expand our categories. I will only discuss this in relation to materials handling, but this approach was taken in other areas as well.

We broke our minor categories into major element such as:

2.4 Material handling
2.41 Operate M.H.E. empty
2.42 Operate M.H.E. loaded
2.43 Load or unload M.H.E.

And

3.4 Wait for M.H.E. equipment
3.41 Wait to use equipment
3.42 Look for equipment

If we review the information that we said was necessary to make a thorough appraisal of our materials handling situation:

Who is spending How Much Time on material handling?
What is the total labor lost attributable to material handling?
How much time is spent on each of the major elements of material handling?
Who is using What equipment?

we find that we have the answers to our first three questions, but not the last one: "Who is using What equipment?"

In order to obtain this information, we subdivided the major elements into minor elements representing the various forms of material handling present in the organization. These were:

1. Crane
2. Fork truck
3. Monorail hoist
4. Hand truck
5. Hand carry

Thus if a machine operator was observed pulling a hand truck, this activity was to be recorded as: 2.424

2 - support operation
4 - material handling
2 - operating equipment loaded
4 - hand truck

And if a set-up man was observed waiting to use a monorail hoist, this activity was to be recorded as: 3.413

3 - delay
4 - material handling
1 - wait for equipment
3 - monorail hoist

Most of the categories discussed are readily

understood, but in order to insure consistency, we drew up definitions of each category which indicated the starting and ending points of the category as well as what was included in the performance of the category. I can't over-emphasize the necessity for such a procedure, especially when the data taken by several analysts is to be compared.

The data was to be collected plant-wide by 17 analysts. Since we knew that we would want to summarize and compare this data in many different ways, we decided that the best media for recording the individual observations would be a punched card.[6]

Master cards were prepared for each employee indicating his name, labor classification (operator, set-up man, etc.) and work center code. After each analyst determined the amount of time required between cycles of observations and the number of cycles he should make each day, master tables of random times reflecting these requirements were drawn up and punched into cards. A date card, the appropriate random time deck and the master employee deck for each area were then used to reproduce the detailed observation cards needed for each day. To insure randomness, the detail cards were sorted for each cycle of observations on a different letter in the employee's name - i.e. first initial, second initial, first letter of last name, second letter of last name, etc.

The mechanics of taking the study were fairly simple. At the time indicated on the cards, the analyst began a cycle of observations, recording what each employee was doing by mark sensing the appropriate category number on the detail observation card. The employees were observed in the same order as the card arrangement. This was necessary because of the relatively long time required to determine the proper category designation for each employee (sometimes the category could only be determined from discussion with the employee) which would have made it possible for employees to "get set" for the analyst if observations were always made in the same order.

Just a word about the number of observations required for such a study. We did say we wanted our results to be accurate within an arbitrary plus or minus 5 or 10%, but rather established tolerance ranges in terms of "pure" percentage or a "precision interval" as Mr. Aldridge[6] expresses it. Different ranges were established for the various subdivisions of categories and for the size of the group about which inferences were to be made, i.e. department, branch or division. We also established a minimum of two weeks for the observation period in order to reduce the effect of that "one exceptional day" and to further reduce cyclic influences we determined that we would use the middle two weeks of a month. It turned out that the two week minimum observation period was more restrictive than the tolerance requirements which is to be expected in a study of this type, where a very precise degree of accuracy is not required and many observations are being made with each cycle.

Enough of the mechanics. Let's see what the study told us about our materials handling situation.

First, let's look at the answer to the question of "Who is spending How Much Time on materials handling?":

SLIDE: OPERATORS % DISTRIBUTION OF TIME
- Direct Production - 63%
- Support - 19%
  - Material Handling - 11%
- Delay - 18%
  - Delay for M.H.E. - 3%

SLIDE: SET-UP MEN % DISTRIBUTION OF TIME
- Set-up and operate - 60%
- Support - 24%
  - Material Handling - 13%
- Delay - 16%
  - Delay for M.H.E. - 5%

SLIDE: FOREMEN % DISTRIBUTION OF TIME
- Supervisory activities -52%
- Non-supervisory activities - 35%
  - Material Handling - 7%
- Away from area - 13%

SLIDE: MATERIAL HANDLERS % DISTRIBUTION OF TIME
- Material Handling - 62%
- Repair, Clean-up, etc. - 20%
- Delay - 18%

The total per cent of time associated with material handling seems very high unless you understand the organization. The Material Handling Branch only moves materials between departments. Operators, Set-up Men or Foremen actually move the material to and from the workplace. Even knowing this, we were surprised at the amount of time spent on material handling.

By knowing how much time each labor classification spends on material handling, we could determine our total annual labor cost associated with this function.

SLIDE: ANNUAL LABOR COST ASSOCIATED WITH MATERIAL HANDLING (Including delays)
Operators - 64.3% ($350,000)
Material Handling Branch - 25% ($135,000) (Includes overhead)
Set-up Men - 7.0% ($38,200)
Foreman - 3.7% ($20,000)
Total: $543,200

You can see that if we only had directed our efforts towards the development of standard data for the material handling branch, we would have missed the largest elements of our material handling cost.

In answer to the question of how much time is spent on each of the major elements of material handling, let's look at the operator's distribution of time by major material handling elements. Similar graphs could have been drawn for the other labor classifications and for the entire organization.

SLIDE: OPERATORS DISTRIBUTION OF TIME ASSOCIATED WITH MATERIAL HANDLING
Operate Equipment Loaded - 30%
Operate Equipment Empty - 22%
Wait for M. H. E. - 21%
Look for M. H. E. - 18%
Load and Unload M. H. E. - 9%

This information is much more valuable to us than just knowing that 14% of the operator's time is spent in material handling or waiting for M. H. E. It provides us with a positive basis for some very obvious corrective action.

Finally we were able to determine who was using what equipment. We did this by sorting our data by labor classification and minor element and got the following results:

SLIDE: TYPE OF MATERIALS HANDLING AND WHO PERFORMS THEM
Crane - 3.0%
- Material Handlers - 3.0%

Monorail Hoist - 14.7%
- Foremen - 0.3%
- Set-up men - 1.2%
- Operators - 13.2%

Hand Carry - 16.8%
- Foremen - 0.3%
- Set-up men - 0.6%
- Operators - 15.9%

Ford Truck - 17.9%
- Foremen - 0.8%
- Operators - 7.3%
- Materials Handlers - 9.8%

Hand Truck - 47.6%
- Foremen - 1.2%
- Set-up men - 2.0%
- Operators - 43.7%
- Material Handlers - 0.7%

This gave us some interesting results. For instance, according to the rules and regulations, only members of the material handling branch were to operate fork trucks.

Since material handling by operators contributed most heavily to our total material handling cost, we were particularly interested in their distribution of time associated with the various types of equipment.

SLIDE: TYPE OF MATERIAL HANDLING PERFORMED BY OPERATORS
Hand Truck - 55%
Hand Carry - 20%
Monorail Hoist - 16%
Ford Truck - 9%

You will notice the significant amount of time material was actually carried by hand.

At a later time when the material handling branch requested the purchase of additional equipment, we became concerned with the utilization of our fork trucks. Again we got the answers to our questions with a work sampling study which yielded the following results:

SLIDE: FORK TRUCK UTILIZATION
In use - 67%
- Loaded - 27%
- Empty - 40%

Idle - 33%
- Loaded - 6%
- Out of service - 8%
- Standing by - 19%

In conclusion, I would like to say, that while the technique of work sampling is relatively simple and easily understood, the design of such an extensive study as we have discussed is a real challenge to the Industrial Engineer.

Such studies cost money, but when compared with the value of the savings which can be effected from the information obtained, the costs become negligible.

The study brought to light the need for many obvious organization and methods changes:

Delivery of material directly to workplace.
Assignment of lower grade material handlers to individual departments, etc.

These and other changes are now taking place. You, as Industrial Engineers, recognize that such changes are not installed overnight. However, soon the Methods and Standards section will be in a position to establish meaningful standards for the material handling activities. They will use elemental data developed primarily from stop watch studies. Again I want to say that they never doubted that such data could be developed. The big question was: "Would such data serve as the medium of control of the material handling costs?" Now they know the magnitude of these costs; it won't be long before standard will be developed in those areas where they will be most effective and the limitations of what can be accomplished with these standards will be known in advance.

So, indeed: "Time Study Analysts - Go to work on Material Handling" - it's a fertile area for your attentions. But before you did invest a little time in a detailed analysis of ALL your material handling costs. You'll find the investment repaid many times.

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APPLICATION II

MAXIMUM PERFORMANCE IN A DAY WORK PLANT

Reprint From:

Third Annual Management Conference
American Institute of Industrial Engineers
Fort Wayne, Indiana
May 2, 1957

By: Ralph S. Kirwin
Ernst & Ernst

The subject Maximum Performance in a Day Work Plant may be discussed from both a qualitative and a quantitative viewpoint either or both of which may have been the thought of the Program Committee in selecting this subject. All too frequently we associate maximum performance, as such, with any system of wage payment based upon results rather than over-all elapsed time. There is a logical reason for this concept, in that the most common transition of work measurement application is from day work or time measured to an output measured basis.

From a quantitative standpoint it might be helpful in our discussion to examine a few of the most common ground rules or principles upon which performance can be appraised. It is not the thought that the principles enumerated are all inclusive, but have been selected as having a direct application upon day work operations generally. A study of day work operations does not preclude some basis of measurement to establish a base of performance effectiveness. Therefore, these principles of effective performance have equal applicability regardless of whether applied to a day work or payment-by-results operation. In any attempt to define a set of principles of work economy or effective performance, it is apparent from a little research upon the subject that each writer has his own set of principles. So with a little reflective thinking you will have a formidable list of principles all purporting to be basic in importance. Therefore, we may expect a challenge upon any set of principles enumerated depending on what our concept of basic is.

All of the principles may be encompassed briefly in few works namely, what are the factors which will collectively contribute to a reduction in cost of the process, product or service as the case may be. However, for ease of discussion of the qualitative aspects of this subject a series of principles have been formulated as follows:

I. PRINCIPLE OF PRODUCTIVITY

To assure a continuing high standard of living for all classes of our population, it is essential that we recognize as a prerequisite a steady increase in the productivity of all human efforts.

II. PRINCIPLE OF EFFECTIVE WORK PATTERN

The whole industrial work pattern to be effective requires that both physical and psychological conditions encountered shall draw forth a spontaneous work behavior response.

III. PRINCIPLE OF GOOD INDUSTRIAL RELATIONS

An essential element of effective work performance is that of mutual confidence and agreement between all human segments of the industrial picture, analogous to the lubricant that permits smooth functioning of two metallic bearing surfaces with minimal friction or heating.

IV. PRINCIPLE OF JOB INTEREST

Unless interest in the task and/or the task situation on a positive participational basis is generated or maintained then the inevitable increase of job aversion fatigue and employee disinterest will adversely affect output performance.

V. PRINCIPLE OF MACHINE UTILIZATION

In general, a machine should be used to its full productive capacity and machine idle time should be kept at a minimum.

VI. PRINCIPLE OF EFFECTIVE WORK AREA

The work area space from a physiological viewpoint divides into two continuous areas which merge from either a left or right handed functioning into a dual handed operation immediately in front of the employee.

VII. PRINCIPLE OF NORMAL WORK AREA

The first or normal work area covers a space served by the forearms and encompasses a circular chordal area approximating 48" wide and 13-1/2" deep.

VIII. PRINCIPLE OF SERVICE AREA

The second or service area covers a circular space, contiguous too but outside the normal area, approximating 66" wide and 25" deep which may be reached at full arm length with minimum body assistance.

IX. DIAGRAM OF EFFECTIVE WORK AREA
(Illustration by Photostat)

X. PRINCIPLE OF HUMAN MOTION ECONOMY

Human motions should be performed by the fastest moving body member/s consistent with eurythmic movement and fatigue reduction.

XI. PRINCIPLE OF VISUAL CONTROL

Consistent with the intensity of visual control required to perform the operation, visual control should be utilized and restrained within the area of normal vision.

XII. PRINCIPLE OF PHYSICAL WELL BEING

Within the compass of any work measurement system, commensurate time should be included to maintain effective performance without any short or long time ill effects on employee health.

XIII. PRINCIPLE OF ACCEPTANCE

Maximum performance is the result of the comprehensive interplay of both tangible and intangible factors which combine toward a common objective. Intangible factors include: physical adaptation to the task, psychological orientation to the task, acceptance by the team, etc.

XIV. PRINCIPLE OF CONTROLLED QUALITY

Maximum performance presupposes the maintenance of established quality requirements and standards.

XV. PRINCIPLE OF PHYSICAL WORKING CONDITIONS

Maintenance of adequate physical working conditions assumes added significance as a contributory factor pertinent to maximum performance.

XVI. PRINCIPLE OF COMMENSURATE COMPENSATION

"Something for Nothing" is the surest way to foredoom all performance measurement efforts to mediocrity. Measurement of performance presupposes a comparable measure of work content in each job in exchange for wages paid.

XVII. PRINCIPLE OF JOB TRAINING

The establishment of efficient work place facilities and production tooling presupposes that employee job training will be oriented in the effective use of these facilities.

XVIII. PRINCIPLE OF SUPERVISORY JOB INTEREST

In parallel with the principle of employee training runs the principle of supervisory job interest. Without supervisory participation and direction, the efforts directed toward efficient work performance and work space utilization will fail to achieve the anticipated maximum performance when supervisory job and personnel interest is lacking.

Turning to the other viewpoint of this subject or the quantitative aspect, the question quite naturally arises what results can be reasonably expected from applying the aforementioned principles to a specific case? This question is in a similar category to the one- how high is up? So our first conclusion is - that it all depends upon the level of comparison by which we measure the results. To clarify this last statement the following example will illustrate the level-of-comparison point under discussion:

XIX. MEASUREMENT BASIS

Day Work Pace	Incentive Pace
100% (Performance Base)	135%
74%	100% (Performance Base)
Day Work Performance	Maximum Incentive Performance

Or, stated another way shall we set the measurement base so that performance in a day work operation is normal or 100% or shall maximum performance under an incentive payment plan be 100%. In the latter case a day work measurement base would be about 74% of an employee's maximum pace.

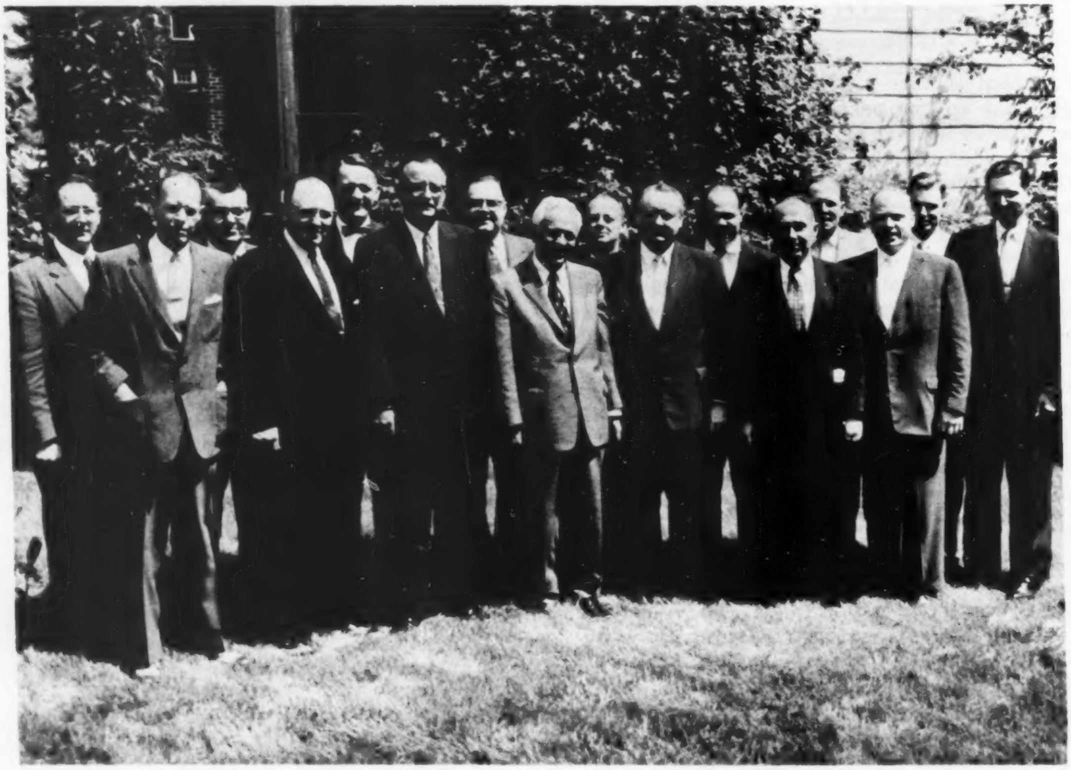
For purposes of this discussion let us assume that maximum performance on a sound measurement basis in a day work plant will be 100% performance. Under this assumption it is a matter of expectancy then that the same measured tasks will be performed at maximum output under the influence of an incentive at a performance level somewhere between 125% to 140%.

Within the foregoing assumption, results of work measurement in a day work plant have shown a wide range of accomplishment. However, anticipated results will fail to materialize in direct ratio to the extent that the principles previously mentioned are neglected or purposely slighted.

Experience has demonstrated in many varied industries under widely divergent climatic and economic conditions that the transition from an unmeasured day work basis of work output to a measured basis will range from 35% to 70% as unmeasured, to 85% to 100% on a measured day work basis. To further support these percentages that the basis of measurement was fair and attainable, the introduction of an incentive system of "payment by results" resulted in performance percentages ranging from 120 to 145.

To summarize the foregoing results in another way, reasonable day work expectancy on a measured basis may show an improvement in productivity of from 140% to 240% in relation to the unmeasured basis. Against this potential improvement should be equated the cost of installation and maintenance of all the factors that make maximum performance in a day work plant an attainable objective.

BOARD MEETING ATTENDEES, May 24, 1957



Front row (left to right): C. H. Van Horne, Stevenson & Kellogg, Ltd.; D. W. Karger, The Magnavox Company; H. B. Maynard, Methods Engineering Council; President Benjamin Borchardt, Benjamin Borchardt & Associates; Seth L. Winslow, A. T. Kearney & Company; Serge A. Birn, Serge A. Birn Company; Robert Isaacson, Argus Cameras. Second row (left to right): Richard F. Stoll, Executive Secretary, MTM Association; James A. Gage, University of Michigan; William K. Hodson, Methods Engineering Council; Donald Farr, Methods Engineering Council; William McIntire, Westinghouse Electric Corporation; Ted Snakenberg, Deere & Company; Richard Keenan, International Harvester Company; T. R. Bunnell, Sylvania Electric Products; and Malcolm Gotterer, Harvard University.

ANNOUNCEMENT

NEXT BOARD MEETING

The MTM Association Board of Directors will meet July 29, 1957, in Chicago, Illinois.

CHAPTER NEWS

MTM ASSOCIATION OF SOUTHERN CALIFORNIA

May Meeting

The May meeting's subject was "MTM in a Bathing Suit" by Robert Andersen of Catalina, Inc.

Mr. Robert Andersen is one of the two men responsible for putting MTM in a bathing suit. He gave some interesting applications on how and why MTM will work for needle trades.

June Meeting

Mr. Tom Arnold, who is Chief Industrial Engineer of the Max Factor Corporation, addressed the Chapter on, "How Shall We Use This Tool?"

ST. LOUIS CHAPTER

May Meeting

The topic for the May 31, 1957, meeting was a film on "MTM In Metal Working Industries."

This film illustrates the use of MTM to various operations including Assembly Work, Punch Press, Machine Shop, etc.

June Meeting

The June 13, 1957, meeting was a tour. Plans for 1958 Program were discussed.

INTERNATIONAL MTM MEETINGS

Juin 25 - 27, 1957 Paris

Mardi 25 Juin (Tuesday June 25)

I. Assemblee Constitutive du Directoire (Organization meeting of International MTM Directorate)

Lieu de Reunion: Maison des X, 12 rue de Poiters, Paris (Place of meeting)

Dejeuner de 12 h. 30 a 14 h. (Luncheon from 1230 to 1400)

Assemblee de 14 h. a 16 h. (Meeting from 1400 to 1600)

Mercredi 26 Juin (Wednesday June 26)

II. Special Reunions en avant Research et Qualification Cooperation (Special meetings on Research and Qualification cooperation)

Lieu des Reunions: Centre Audio-Visuel de l'Association Francaise pour l'Accroussement de la Productivite 21 rue Clement Marot, Paris (Place of meeting)

Debut de Reunions: 14 h. (Meeting begins 1400)

Juidi 27 Juin (Thursday June 27)

III. Special Reunions en evant Education et Publicite (Special meetings on Training and Public Relations)

Lieu des Reunions: Centre Audio-Visual (Place of meetings)

Debut des Reunions: 14 h. (Meetings begin 1400)

IV. Reunion Pleniere (Plenary Session)

Debut de Reunion - 16 h. (Meeting begins 1600)

6th ANNUAL INTERNATIONAL CONFERENCE
September 25, 26, 27, 1957 - Hotel Statler
New York City

*** PROGRAM ***

HOW TO SESSIONS ON
- Selling MTM to Management, Supervision, Union & Worker
- Negotiation and Arbitration Where MTM is in Usage
- Applying MTM in Electronics, Machine Shop, Small Assembly & Job Shop

***

TECHNICAL SESSIONS ON
- Development of MTM Management Techniques
- Specifics of MTM Usage in Maintenance, Clerical & Equipment Design
- Research Techniques and Future Development

***

SEMINARS ON
- Government Usage of MTM
- Functional - Machining, Assembly, Needle Trades & Woodworking
- Special Problems Confronting Registered Practitioners

RESEARCH REPORTS

R.R. 101 Disengage

This report contains a preliminary study of the element disengage. While it is still classified as tentative, the report contains some extremely interesting conclusions on the nature and theory of this element.

R.R. 102 Reading Operations

The first step in the use of MTM for establishing reading time standards is contained in this report. In addition, the report contains a synopsis of the work done in this field by 11 leading authorities.

R.R. 104 MTM Analysis of Performance Rating Systems

A talk presented at the SAM-ASME Time and Motion Study Conference, April 1952. It contains an analysis of performance rating systems and various performance Rating Films from an MTM standpoint.

R.R. 105 Simultaneous Motions

This report represents almost two man-years' work on a study of Simultaneous Motions. It is a final report of the Simultaneous Motions project undertaken by the MTM Association. While it does not purport to provide complete and exhaustive answers to all problems in the field of Simultaneous Motions, it presents a great deal of new and valuable information which should be of interest to every MTM practitioner.

R.R. 106 Short Reaches and Moves

This report contains an analysis of the characteristics of Reaches and Moves at very short distances. It develops important conclusions concerning the application of MTM to operations involving these short distance elements.

R.R. 107 A Research Methods Manual

The research activity of the Association has developed an effective and comprehensive set of methods for carrying on research in human motions. This report details the major techniques used. Adequate sources of motion data, film analysis, data recording, and statistical methods of analysis are among the topics discussed.

R.R. 108 A Study of Arm Movements Involving Weight

In this report, the results of a large investigation into the effect of weight on the performance times of arm movements are presented. While more effective means of determining correct time allowances for moving weights are given, the comprehensive discussion of the whole area of weight phenomena is probably of more fundamental importance. The effect of such conditions of performance as the use of one or two hands, sliding vs. spatial movements, and male and female performance are among the topics presented.

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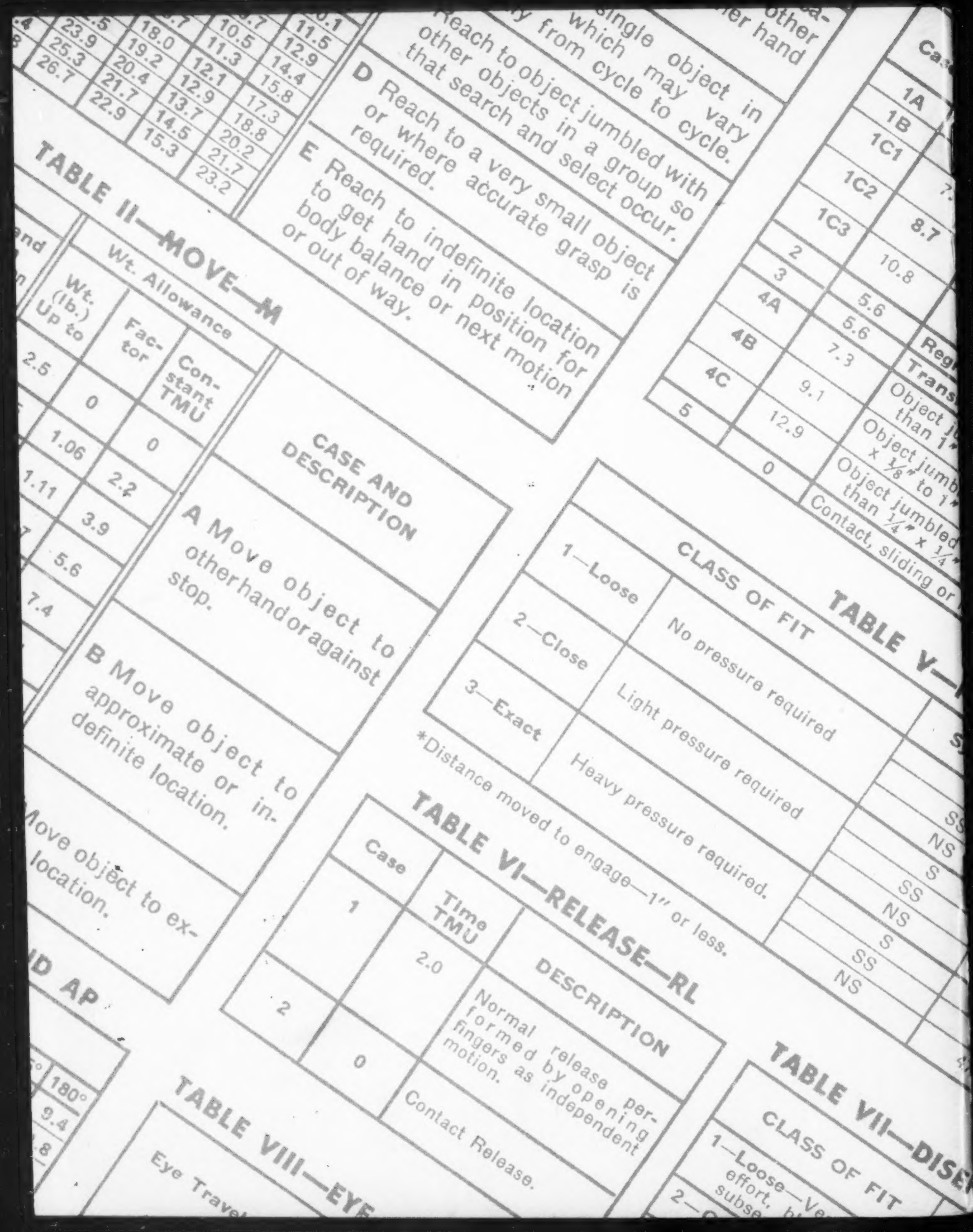
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					



Reach to single object in location which may vary slightly from cycle to cycle.
C Reach to object jumbled with other objects in a group so that search and select occur.
D Reach to a very small object or where accurate grasp is required.
E Reach to indefinite location to get hand in position for body balance or next motion or out of way.
TABLE II—MOVE—M
Wt. Allowance
Wt. (lb.) Up to
Fac-tor
Con-stant TMU
CASE AND DESCRIPTION
A Move object to other hand or against stop.
B Move object to approximate or indefinite location.
Move object to exact location.
TABLE V—
CLASS OF FIT
1—Loose
No pressure required
2—Close
Light pressure required
3—Exact
Heavy pressure required.
*Distance moved to engage—1" or less.
TABLE VI—RELEASE—RL
Case
Time TMU
DESCRIPTION
1
2.0
Normal release performed by opening fingers as independent motion.
2
0
Contact Release.
TABLE VII—DISE
CLASS OF FIT
TABLE VIII—EYE
Eye Travel